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Methods of Distinguishing Larval Alewife (Alosa pseudoharengus) from Larval Blueback Herring (A aestivalis)

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METHODS OF DISTINGUISHING LARVAL ALEWIFE (*ALOSA PSEUDOHARENGUS*) FROM LARVAL BLUEBACK HERRING (*A. AESTIVALIS*)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Larval alewife and blueback herring may be distinguished by differences in the relative position of the vent. Regressions of two characters on SL (the distance between the snout and the vent, and between the vent and the urostyle) are diagnostic for specimens from hatching to 15 mm SL. The regression of the distance from the vent to the margin of the caudal fin distinguishes specimens less than 11.5 mm SL. The number of preanal myomeres, myomeres between the cleithrum and the vent, and myomeres between the insertion of the dorsal fin and the vent may be used to identify larvae between 5.7 and 15 mm SL. Methods of distinguishing larval alewife and blueback herring from commonly associated species in Chesapeake Bay estuaries are also discussed.

Methods of distinguishing larval alewife (*Alosa pseudoharengus*) from larval blueback herring (*A. aestivalis*)

INTRODUCTION

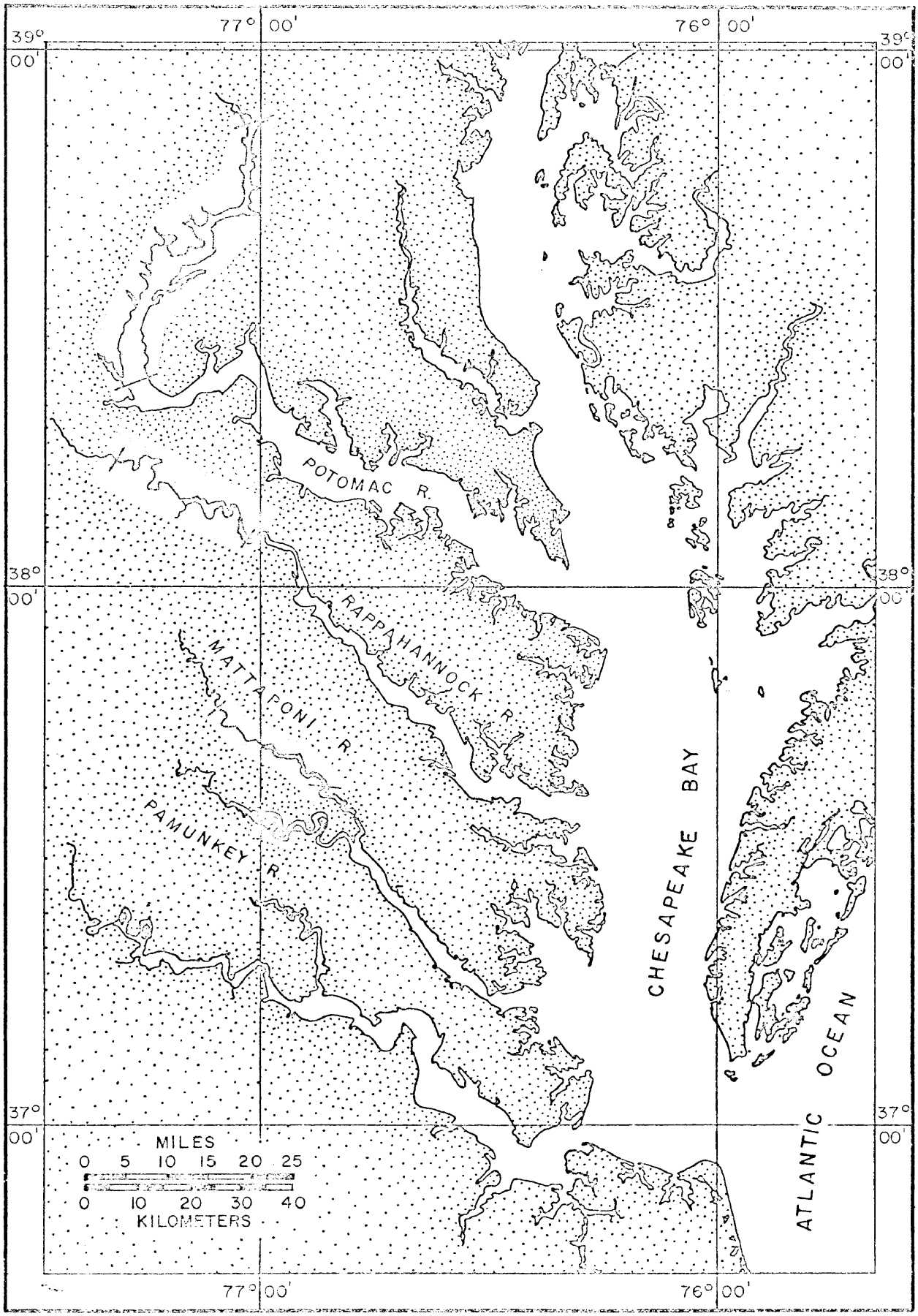
Adequate methods have not been available for distinguishing larval alewife (Alosa pseudoharengus) from blueback herring (A. aestivalis), both of which are abundant in the estuaries of Chesapeake Bay. Identification of larvae from this area is complicated by the presence of American shad (A. sapidissima), hickory shad (A. mediocris), gizzard shad (Dorosoma cepedianum), menhaden (Brevoortia tyrannus), and bay anchovy (Anchoa mitchilli). Descriptions and illustrations of the yolk-sac larvae of alewife and blueback have been published (Kuntz and Radcliffe, 1917; Hildebrand, 1963; and Mansueti and Hardy, 1967). However, blueback between 5.2 and 20.5 mm TL, and alewife between 5.3 and 15 mm TL are undescribed. Moreover, the illustrations of alewife 15 and 16.5 mm (Prince, 1907) are inadequate. This paper describes criteria for distinguishing larval alewife from larval blueback herring.

MATERIALS AND METHODS

Larval clupeids were examined from 306 plankton samples collected from 1 May to 8 August 1967 in the Pamunkey, Mattaponi, and Rappahannock Rivers; and in the Potomac River from 23 April to 19 June 1968 (Fig. 1). Specimens were preserved in five percent buffered formalin and measured under a dissecting microscope with an ocular micrometer. Illustrations (Figs. 5-8) were made with the aid of a camera lucida. Terminology of life history stages follows that recommended by Ahlstrom and Ball (1954), and methods of counting myomeres and measuring specimens adhere to procedures outlined by Mansueti and Hardy (1967). Length refers to standard length (SL) unless specified otherwise.

Alewife and blueback are the predominant clupeid species found in tidal fresh water of the estuaries sampled. Alewife precede blueback on their spawning runs into fresh water by four to five weeks. Preliminary comparisons of larvae collected throughout the spawning season indicated the presence of two similar but morphologically distinct groups. The first group, obtained early in the season, was tentatively identified as alewife; and the second group, appearing in collections late in the season, was designated blueback. Hatching larvae were collected in areas where only alewife were known to be spawning and were found morphologically similar to the early-spawned group. Yolk-sac larvae having the same morphology as the late-spawned group were obtained late in the season in areas where

Figure 1. Areas (shaded) from which samples were collected.


77° 00'
76° 00'
39° 00'
38° 00'
37° 00'
POTOMAC R.
RAPPAHANNOCK R.
MATTAPONI R.
PAMUNKEY R.
CHESAPEAKE BAY
ATLANTIC OCEAN
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS

only blueback were known to be spawning. These findings support the identification of the first group as alewife and the second as blueback. Specimens from samples containing both types of larvae were identified by their morphological similarity to one of the two groups. Other species appearing in the collections (notably American shad and bay anchovy) were distinguished by criteria discussed later in the paper.

Many counts and measurements were alternately examined and rejected until 11 characters were found which were consistent within each group and sufficiently different to allow assignment to species. Three meristic and three morphometric characters were selected for statistical analysis. Data from 133 alewife and 112 blueback were divided into 10 samples using three criteria: species, specimen length, and river of collection (Table 1). The specimens exhibited allometric growth; consequently, the data for larvae less than or equal to 12.0 mm were compared only with each other as were the data for larger specimens.

The following morphometric characters were compared with standard length by regression analysis: the distance from the snout to the posterior margin of the vent, the distance from the posterior margin of the vent to the urostyle, and the distance from the posterior margin of the vent to the posterior margin of the tail. All values were transformed to logarithms to reduce the correlation between the variance and the mean (Mottley, 1941).

Table 1. Designation of samples used in the analysis of meristic and morphometric data from 133 alewife and 112 blueback herring collected in four Chesapeake Bay estuaries, 1967-68.

River of	Alewife		Blueback	
collection	≤ 12.0 mm SL	> 12.0 mm SL	≤ 12.0 mm SL	> 12.0 mm SL
Potomac	A_1	A_2	B_1	
Rappahannock	A_3	A_4	B_2	B_3
Mattaponi	A_5			
Pamunkey	A_6		B_4	
Combined	A_S	A_L	B_S	B_L

Every sample was tested against each of the others by analysis of covariance (Snedecor, 1956:394). After the significance level of intraspecific variation was determined, interspecific comparisons were made. These tests were conducted for individual and combined samples containing larvae of comparable length.

Two meristic characters, the number of preanal myomeres and the number of myomeres between the cleithrum and the posterior margin of the vent, were tested by analysis of variance (Snedecor, 1956:237). Since this test indicated significant mean difference (one percent level), Duncan's Multiple Range Test (Duncan, 1957) was conducted to group those samples whose means were not significantly different (one percent level). Of the 245 larvae used in the morphometric analysis, 90 alewife and 62 blueback were suitable for meristic comparison. Specimens less than 5.7 mm long were excluded from the analysis because their anterior myosepta were so poorly differentiated that one or more myomeres were likely to be missed in counting. Also excluded were 22 poorly preserved alewife (14.4 to 23.7 mm long) whose myomeres could not be counted accurately.

The third meristic character investigated was the number of complete myomeres between imaginary vertical lines drawn at the insertion of the posterior ray of the dorsal fin (or insertion of the dorsal fin anlage), and at the posterior margin of the vent. Fifty specimens of each species were used in the analysis. The range in standard length was 5.8 to 16.2 mm for alewife and 6.5 to 13.3 mm for blueback.

RESULTS

Regressions of the distance from snout to vent on SL (Fig. 2), the distance from vent to urostyle on SL (Fig. 3), and the distance from vent to tail on SL (Fig. 4) distinguished larval alewife from blueback herring. Each regression was curvilinear. Slope inflection was caused by the interaction of two factors: development of the caudal fin and urostyle (Figs. 5 to 8), and anterior migration of the vent with increased specimen size. Equations for the linear portion of each regression are given in Table 2.

Results of analysis of covariance for each character (Table 3) indicate that differences between the two species are highly significant. With one exception, interspecific comparisons of the regressions of the distance from snout to vent on SL and the distance from vent to urostyle on SL resulted in levels of significant difference exceeding those of intraspecific comparisons. Intraspecific comparisons of the regressions of the distance from vent to tail on SL were influenced by heterogeneous variances and in one case by an extremely poor correlation coefficient. These two results are attributed to the condition of the specimens. In many cases the distance from the vent to the tail (and total length) was estimated for specimens whose delicate caudal finfold had been abraded during collection. The fins of larger fish were little affected because of the support provided by developing rays.

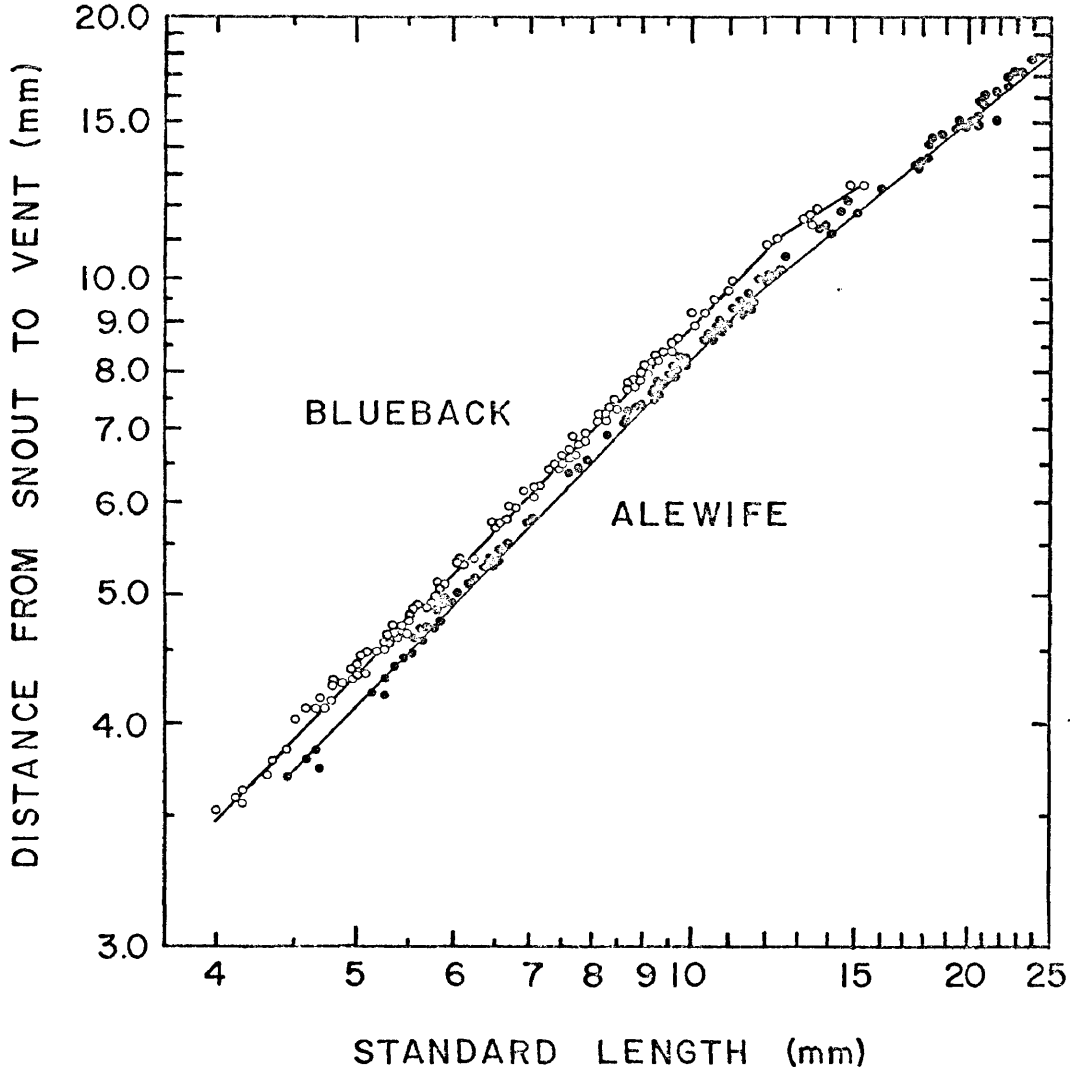


Figure 2. Regression of the distance from snout to vent on SL for alewife and blueback herring.

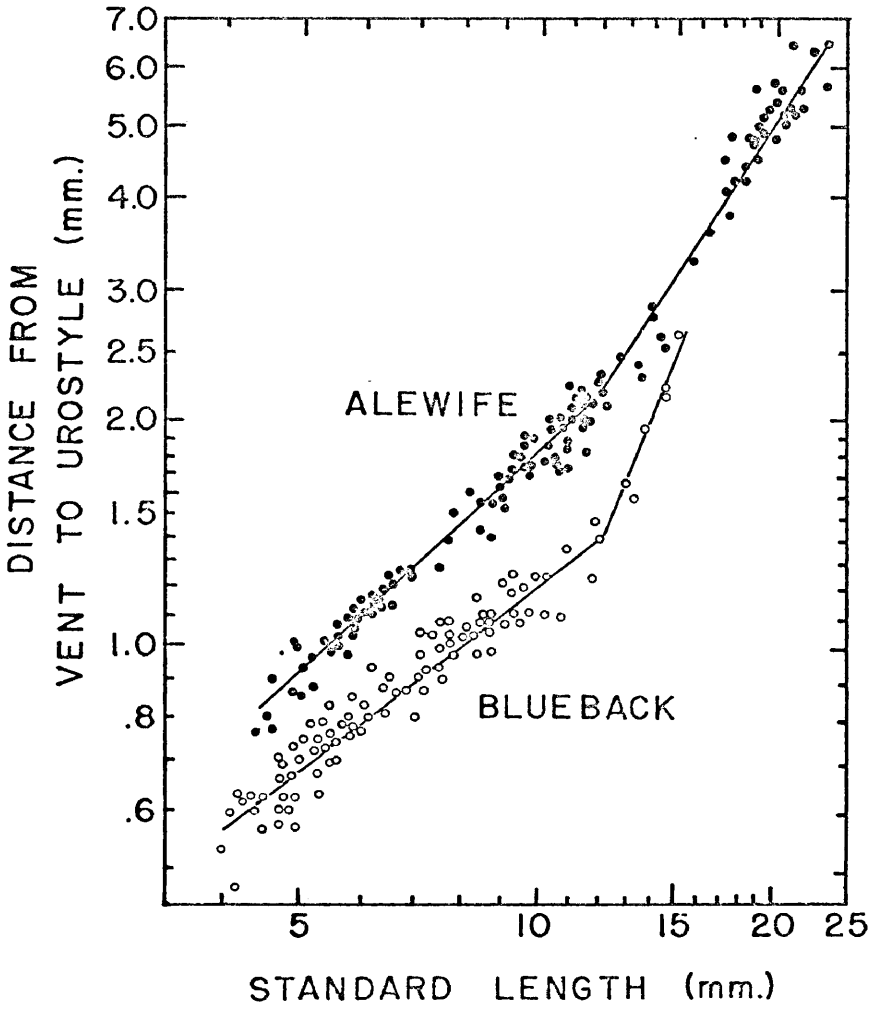


Figure 3. Regression of the distance from vent to urostyle on SL for alewife and blueback herring.

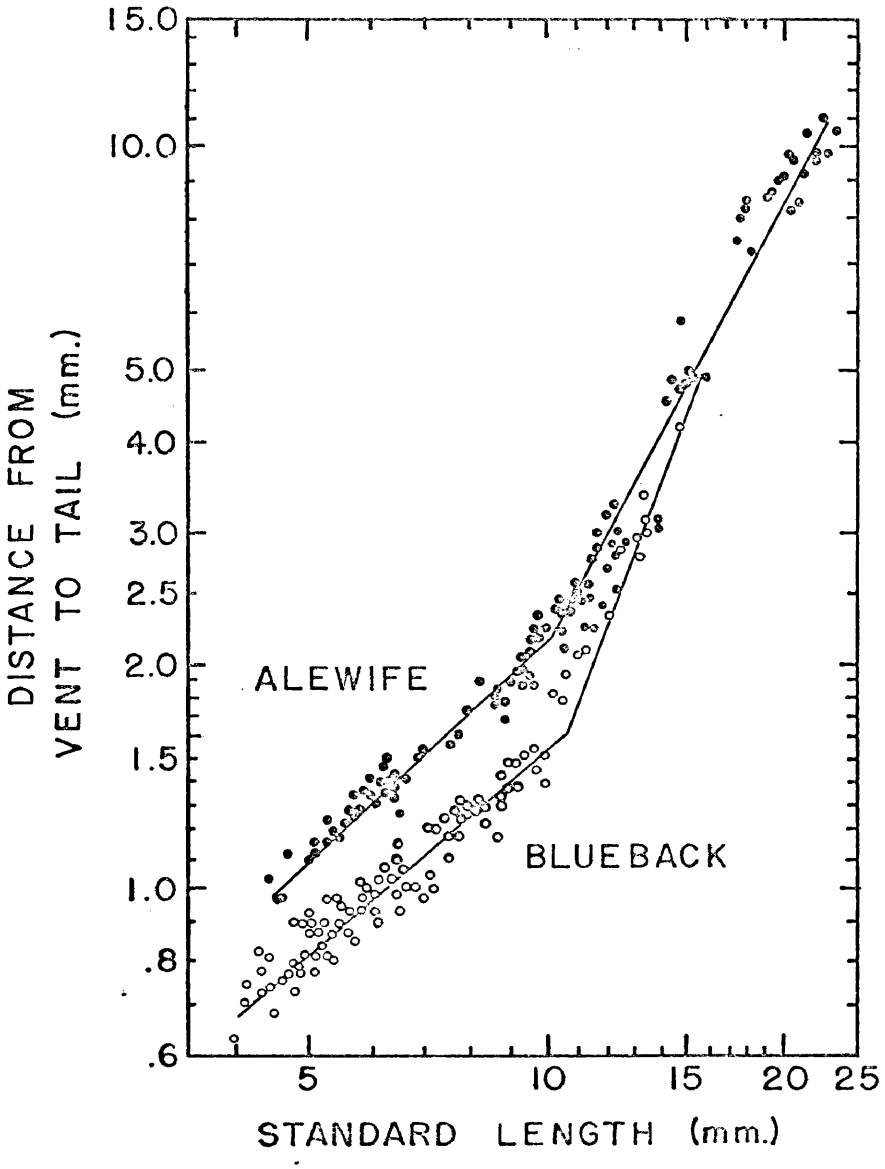


Figure 4. Regression of the distance from vent to tail on SL for alewife and blueback herring.

Figure 5. Larval alewife (A) 5.77 mm SL (6.00 mm TL) and blueback herring (B) 6.50 mm SL (6.68 mm TL).

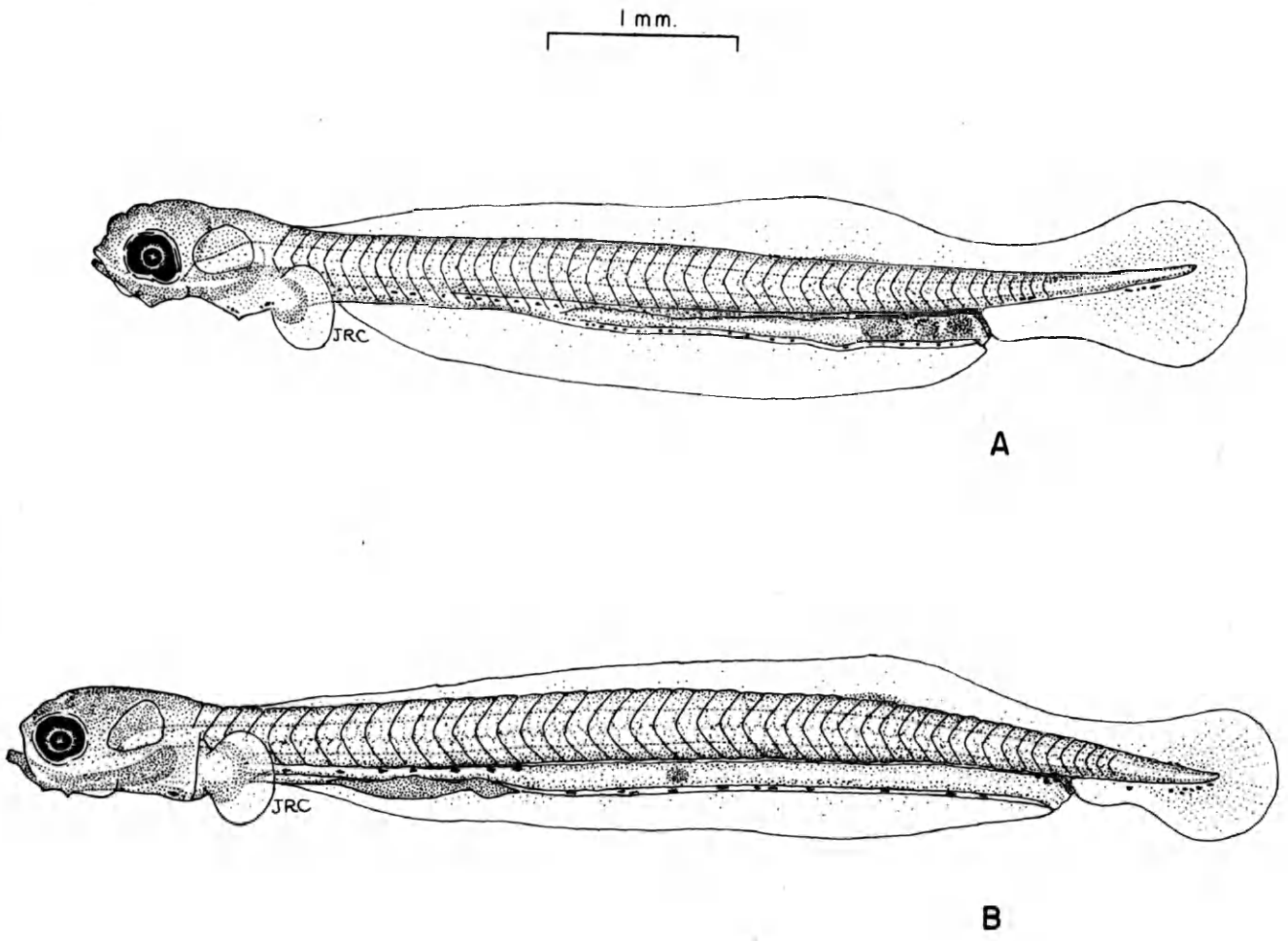

1 mm.
JRC
A
JRC
B

Figure 6. Larval alewife (A) 8.75 mm SL (9.00 mm TL) and blueback herring (B) 8.90 mm SL (9.20 mm TL).

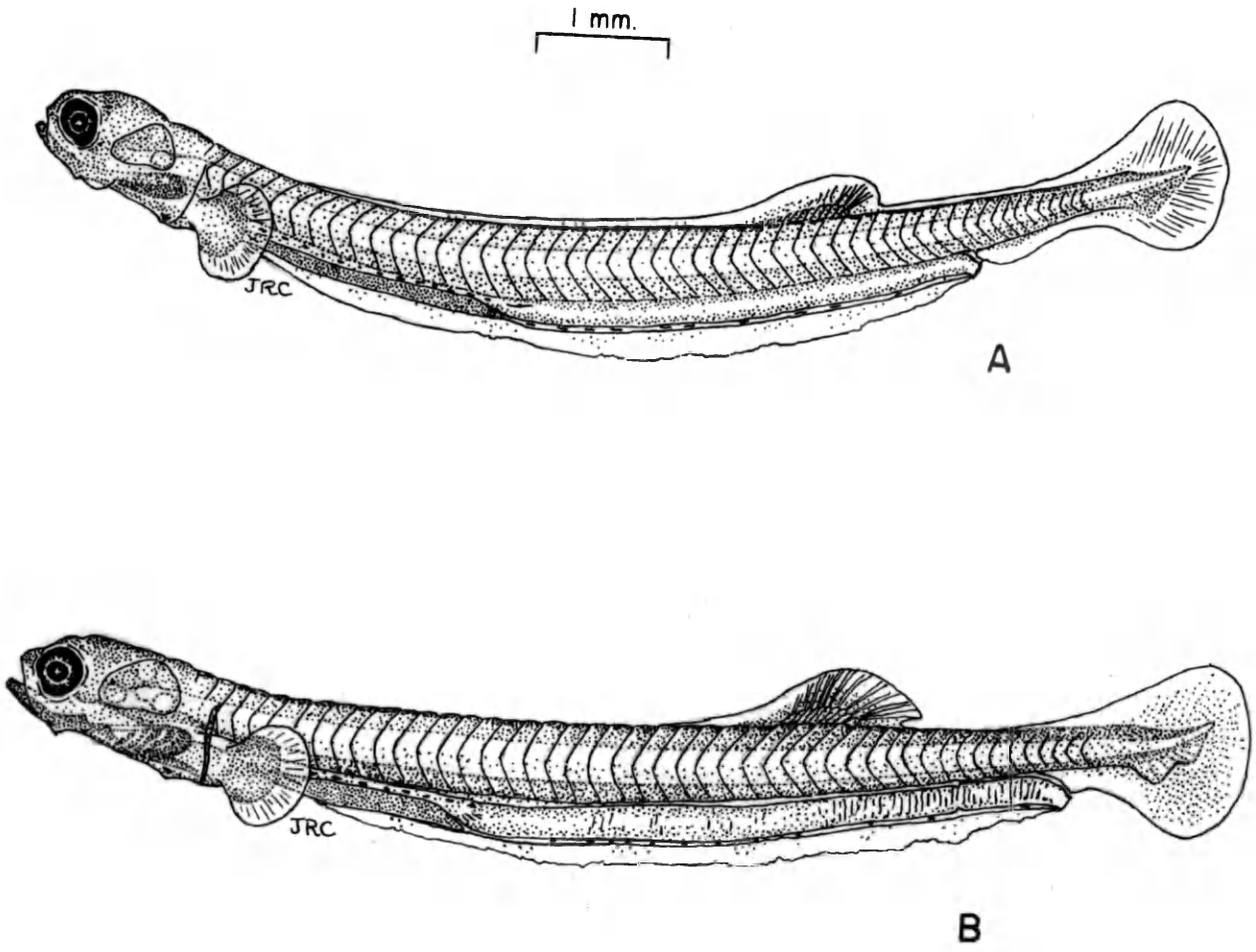

1 mm.
JRC
A
JRC
B

Figure 7. Larval alewife (A) 11.50 mm SL (11.90 mm TL) and blueback herring (B) 11.03 mm SL (11.95 mm TL).

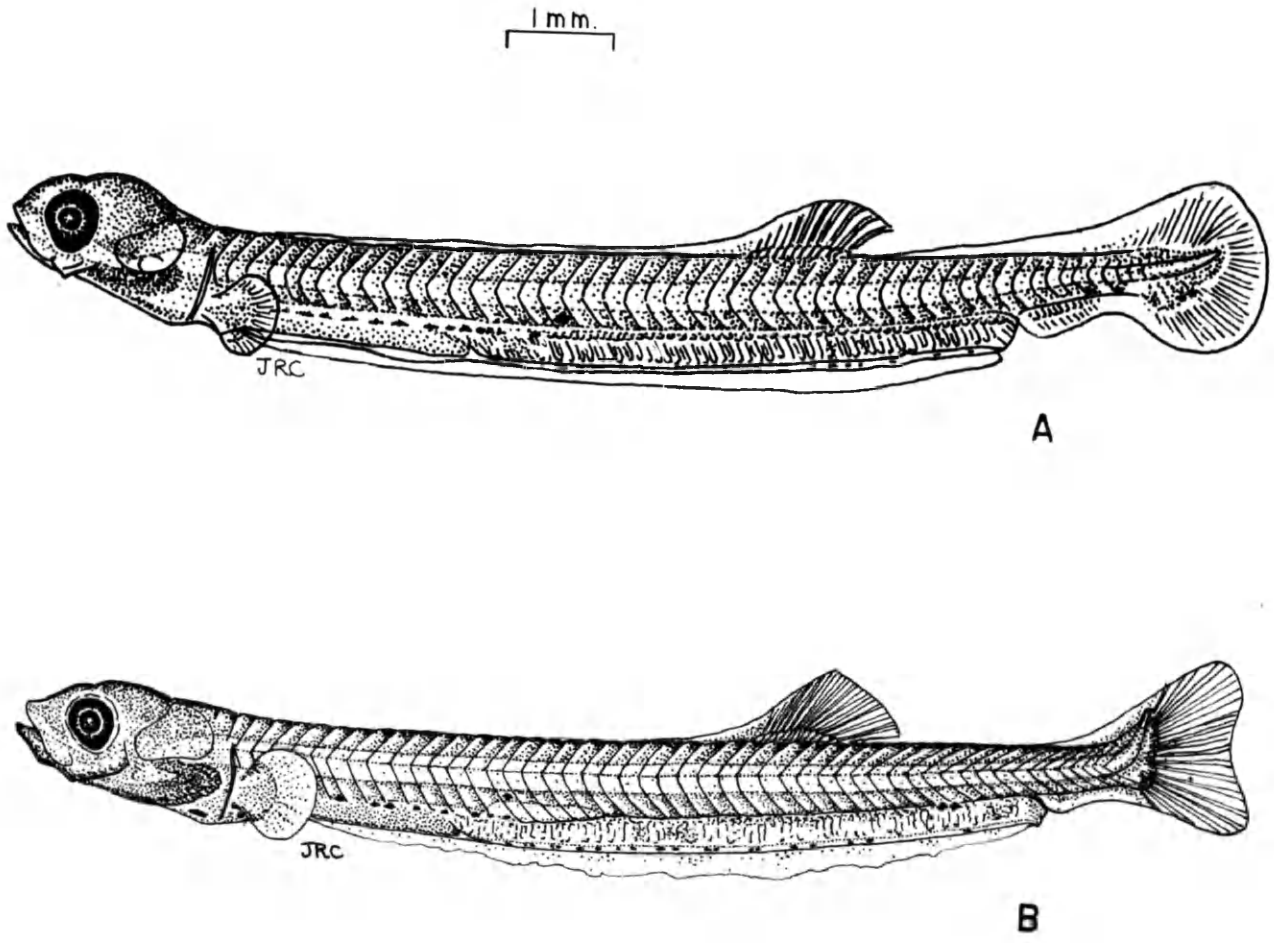

1 mm.
JRC
A
JRC
B

Figure 8. Larval alewife (A) 13.60 mm SL (14.95 mm TL) and blueback herring (B) 13.30 mm SL (14.80 mm TL).

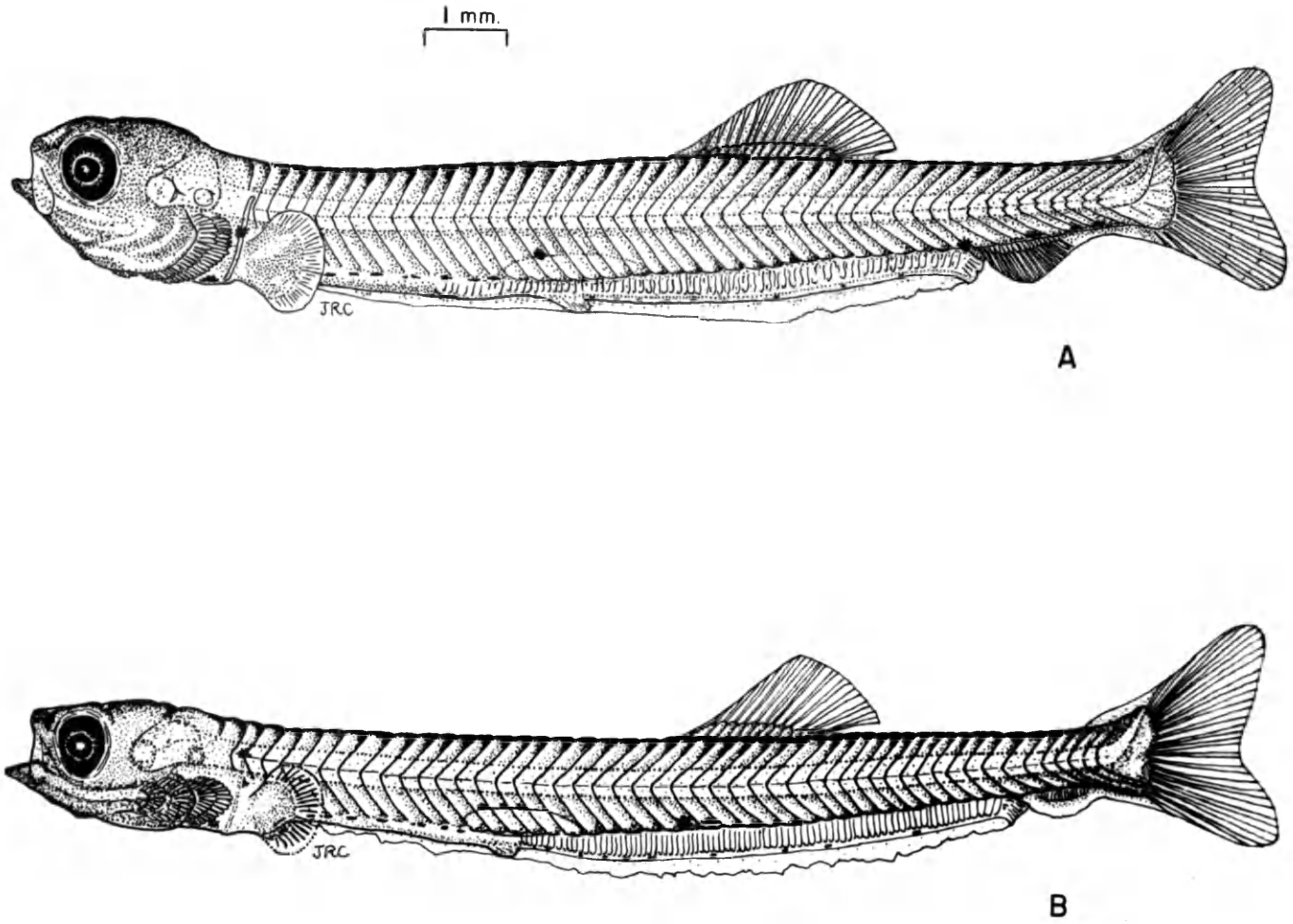

1 mm.
JRC
A
JRC
B

Table 2. Equations for the regressions of the distance from snout to vent, the distance from vent to urostyle, and the distance from vent to tail on SL. The regressions are plotted in Figures 2-4.

Character tested	≤ 12.0 mm SL	> 12.0 mm SL
	Alewife	
Snout-vent distance	logY = -0.098 + 1.017 logX r = 0.99	logY = 0.104 + 0.827 logX r = 0.99
Vent-urostyle distance	logY = -0.714 + 0.961 logX r = 0.98	logY = -1.394 + 1.598 logX r = 0.97
Vent-tail distance	logY = 0.348 + 0.987 logX r = 0.98	logY = -0.670 + 1.999 logX r = 0.96
	Blueback	
Snout-vent distance	logY = -0.079 + 1.026 logX r = 0.99	logY = 0.283 + 0.697 logX r = 0.97
Vent-urostyle distance	logY = -0.750 + 0.826 logX r = 0.94	logY = -3.002 + 2.869 logX r = 0.95
Vent-tail distance	logY = 0.283 + 0.909 logX r = 0.95	logY = -1.692 + 2.839 logX r = 0.96

Table 3. Results of analysis of covariance of the regressions of the distance from snout to vent, the distance from vent to urostyle, and the distance from vent to tail on SL. Significance, unless otherwise noted, refers to differences between adjusted means as follows: not significant (-), $P<0.05$ (*), $P<0.01$ (**), $P<0.001$ (***).

Length class (mm SL)	Sample comparisons	Sample sizes	Snout to vent distance	Vent to urostyle distance	Vent to tail distance
	Intraspecific				
≤ 12.0	A_1 - A_3	59 - 9	*	-	***[1]
	A_1 - A_5	59 - 28	-	-	-
	A_1 - A_6	59 - 7	-	-	-
	A_3 - A_5	9 - 28	-	-	- [1]
	A_3 - A_6	9 - 7	-	-	- [1]
	A_5 - A_6	28 - 7	-	*	-
	B_1 - B_2	32 - 66	***	** Reg.Coef.	***
	B_1 - B_4	32 - 6	-	** Reg.Coef.	*** Var.
	B_2 - B_4	66 - 6	-	-	*** Var.
> 12.0	A_2 - A_4	6 - 24	-	-	-
	Interspecific				
≤ 12.0	A_1 - B_1	59 - 32	***	***	***
	A_1 - B_2	59 - 66	***	***	*** Var.
	A_1 - B_4	59 - 6	***	***	***

Table 3 (continued)

Length class (mm SL)	Sample comparisons	Sample sizes	Snout to vent distance	Vent to urostyle distance	Vent to tail distance
	Interspecific				
≤ 12.0	A_3 - B_1	9 - 32	***	***	***[1]
	A_3 - B_2	9 - 66	***	***	***[1]
	A_3 - B_4	9 - 6	***	***	***[1]
	A_5 - B_1	28 - 32	***	***	***
	A_5 - B_2	28 - 66	***	***	*** Var.
	A_5 - B_4	28 - 6	***	***	***
	A_6 - B_1	7 - 32	***	***	***
	A_6 - B_2	7 - 66	***	***	***
	A_6 - B_4	7 - 6	***	***	***
	A_S - B_S	103 - 104	***	***	*** Var.
> 12.0	A_2 - B_3	6 - 8	***	**	***
	A_4 - B_3	24 - 8	***	**	***
	A_L - B_L	30 - 8	***	***	***

[1]Correlation coefficient (r) was 0.48 for sample A_3, for all other samples r exceeded 0.90.

Differences in the number of preanal myomeres and myomeres between the cleithrum and the vent provided additional means of distinguishing alewife from blueback. Table 4 lists mean myomere counts obtained for each species at one mm size intervals, in addition to data obtained concurrently for 21 American shad. A decline in mean numbers first became evident at 14 mm for both alewife and blueback, a result of the forward migration of the vent as body depth increased prior to transformation. No decline in mean numbers was evident for shad (mode 48, $\bar{x} = 47.6 \pm 0.47\ S\bar{x}$).

Analysis of variance indicated significant differences in the mean number of preanal myomeres among the samples tested. Duncan's test separated all samples of alewife from blueback - (A_2 A_6 A_1 A_3)(A_6 A_1 A_3 A_5)(B_3 B_1 B_2 B_4). Figure 9 illustrates the difference between the two species. Significant difference between samples A_2 and A_5 is correlated with the difference in mean lengths (Table 5).

Mean numbers of myomeres between the cleithrum and the vent were subjected to analysis of variance and were found to differ significantly among the samples tested. Duncan's test separated all samples of alewife from blueback - (A_2 A_3)(A_3 A_6 A_5 A_1) (B_3)(B_2 B_1 B_4). Figure 10 indicates the degree of separation between the two species. Significant difference among samples of the same species is correlated with differences in mean lengths (Table 5).

Table 4. Mean number of preanal myomeres (PAM) and myomeres between the cleithrum and the vent (CVM) of alewife, blueback herring, and American shad.

Size interval (mm SL)	Alewife			Blueback			Shad	
	N	PAM	CVM	N	PAM	CVM	N	PAM
4.0 - 4.9	2	40.0	39.0	4	42.8	41.8	-	-
5.0 - 5.9	19	40.9	39.8	14	42.9	42.2	-	-
6.0 - 6.9	21	41.3	39.6	10	44.0	42.9	-	-
7.0 - 7.9	5	41.8	40.2	15	44.3	42.5	-	-
8.0 - 8.9	6	41.3	40.3	13	44.2	42.9	-	-
9.0 - 9.9	17	40.9	39.7	8	44.2	42.9	2	45.5
10.0 - 10.9	11	41.2	39.4	4	44.2	42.5	2	47.0
11.0 - 11.9	13	40.9	39.5	3	43.7	42.7	2	47.0
12.0 - 12.9	8	40.9	39.6	2	44.0	42.0	2	48.5
13.0 - 13.9	6	40.9	39.1	4	44.0	41.5	2	47.0
14.0 - 14.9	3	40.0	38.0	1	43.0	40.0	1	47.0
15.0 - 15.9	-	-	-	1	42.0	39.0	5	48.2
16.0 - 16.9	1	40.0	37.0	-	-	-	3	48.7
17.0 - 17.9	-	-	-	-	-	-	2	48.0
18.0 - 18.9	1	39.0	36.0	-	-	-	-	-
19.0 - 19.9	1	39.0	35.0	-	-	-	-	-

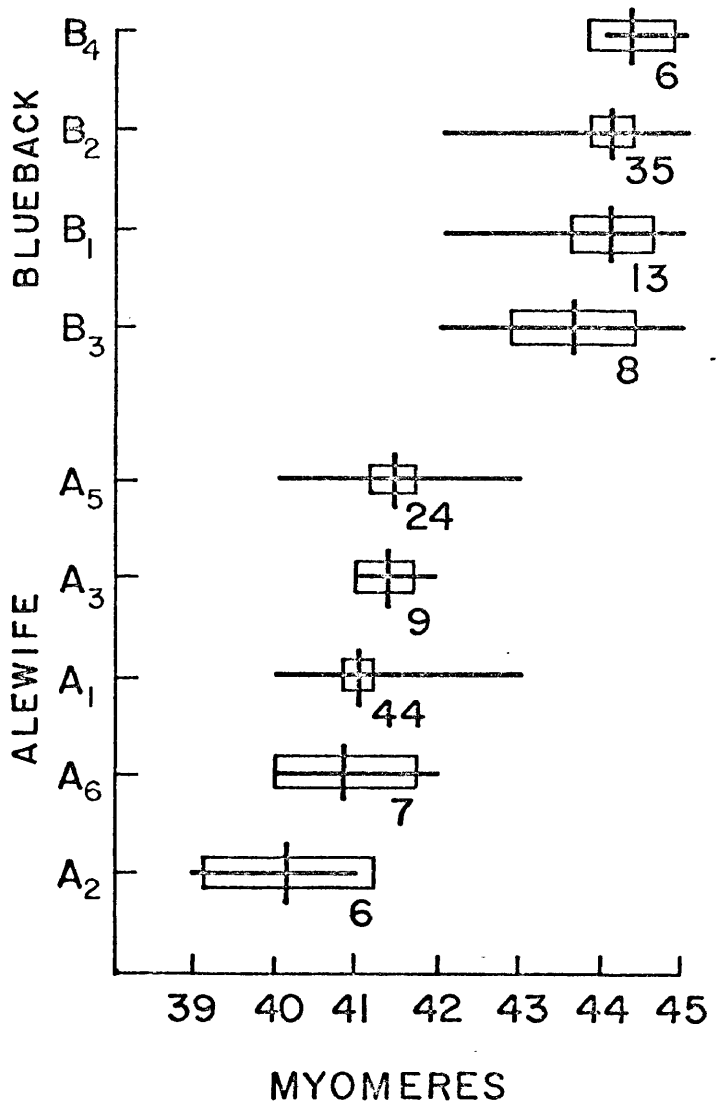


Figure 9. Number of preanal myomeres for samples of alewife and blueback herring tested by analysis of variance. The horizontal line represents the range; the number represents sample size; and the rectangle represents the interval estimate ($S\bar{x}\ t_{.05}$) on the mean, described by the vertical line.

Table 5. Number of preanal myomeres (PAM) and myomeres between the cleithrum and the vent (CVM) for samples of alewife and blueback herring compared by analysis of variance.

Species	Samples	N	Mean length (mm SL)	PAM		CVM	
				mean	range	mean	range
Alewife	A	24	6.5	41.4	40-43	39.6	39-41
	A	44	9.4	41.0	40-43	39.9	39-41
	A	7	9.6	40.9	40-42	39.6	38-40
	A	9	10.8	41.3	41-42	39.2	39-40
	A	6	12.7	40.2	39-41	38.7	37-40
Blueback	B	13	7.8	44.1	42-45	42.9	41-45
	B	35	8.2	44.1	42-45	42.5	42-43
	B	6	8.9	44.3	44-45	43.3	42-44
	B	8	13.5	43.6	42-45	41.1	39-42

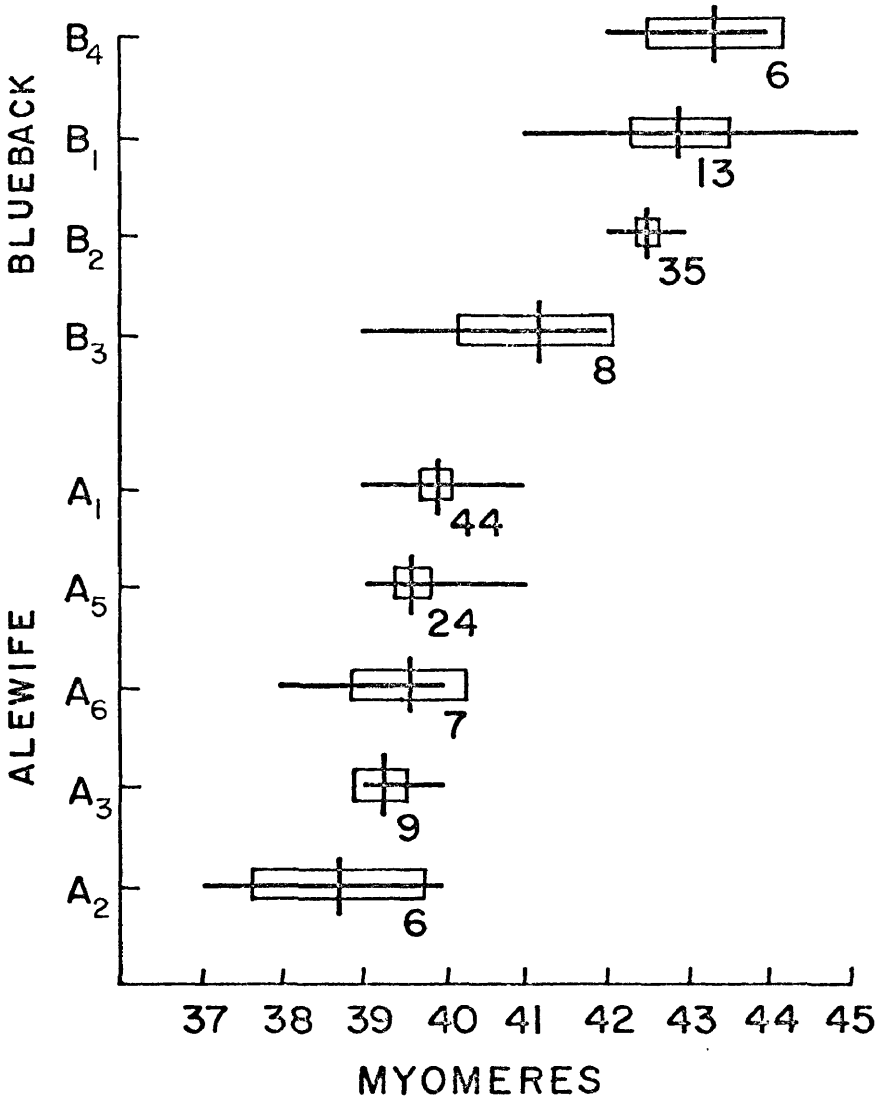


Figure 10. Number of myomeres between the cleithrum and the vent for samples of alewife and blueback herring tested by analysis of variance.

The number of myomeres between the insertion of the dorsal fin and the posterior margin of the vent ranged from 7 to 9 ($\bar{x}$ = 8.0) for alewife and 11 to 13 ($\bar{x}$ = 11.8) for blueback. The variation in counts was not correlated with differences in specimen size.

The following morphometric characters were found unsuitable for diagnostic use because of their high intraspecific variability: the distance between the snout and the cleithrum, and between the snout and the origin of the dorsal fin; head length; head width; head depth; snout length; eye diameter; body depth at cleithrum; and body depth at dorsal fin. Meristic characters, rejected because of their similarity between the two species, were: numbers of total, postanal, and predorsal myomeres; and numbers of rays in the dorsal and anal fins at comparable specimen lengths.

DISCUSSION

Larval alewife and blueback can be distinguished by six characters based on the relative position of the vent. The regressions of the distance from snout to vent on SL and the distance from vent to urostyle on SL are diagnostic for specimens less than 15 mm long. The regression of the distance from vent to tail on SL is more variable, but is useful in distinguishing between larvae less than 11.5 mm long. The number of preanal myomeres and the number of myomeres between the cleithrum and the vent, though tedious to count, permit identification of larvae longer than 5.7 mm. Alewife less than 14 mm SL had a mean of 41 preanal myomeres and 40 myomeres between the cleithrum and the vent, whereas, blueback of comparable size had 44 and 43, respectively. Larger specimens had proportionately lower mean values. The number of myomeres between the insertion of the dorsal fin and the vent is diagnostic, being 7 to 9 in alewife and 11 to 13 in blueback.

Unfortunately, few larvae longer than 15 mm were available for study because they could avoid the plankton net. Further study is needed to determine a method for distinguishing between alewife and blueback at 15 to 30 mm SL. Larger juveniles can be identified by a number of well established characters (Hildebrand and Schroeder, 1928:83; Bigelow and Schroeder, 1953:86; and Hildebrand, 1963:313).

American shad can be distinguished from alewife and blueback

by their large size at comparable stages of development, or conversely, their lack of development at comparable lengths. At any particular stage, shad are approximately two or three times the size of either alewife or blueback. Preanal myomere counts can also be used as a basis for identifying larval shad. Leim (1924:37) used ventral pigmentation patterns to distinguish shad from alewife; this method can also be used to distinguish shad from blueback, whose pigmentation is similar, if not identical, to that of alewife.

Although vast numbers of juvenile alewife, blueback, and American shad have been collected in the fresh water reaches of the estuaries (Hildebrand and Schroeder, 1928; Massmann, et al, 1952; and Massmann, 1953), few young hickory shad, gizzard shad, or menhaden have been observed during extensive sampling by many workers using a variety of gear. None of the larvae examined during this study could be identified as hickory shad (Mansueti, 1962), gizzard shad (Miller, 1960), or menhaden (Mansueti and Hardy, 1967).

Menhaden larvae do not normally occur in tidal fresh water (Massmann, et al, 1954; Massmann, et al, 1962; and Hildebrand, 1963:353). As described by Mansueti and Hardy (1967:66-69), larval menhaden more closely resemble blueback than alewife, especially in the head and jaw morphology (Figs. 5 to 8). The preanal myomere counts given by these authors for menhaden 5.0 to 23.0 mm TL range from 37 to 40, barely overlapping those of alewife but not those of blueback. Menhaden larvae can be

distinguished by the termination of the dorsal fin which is positioned two or three myomeres anterior to the posterior margin of the vent (Ahlstrom, 1968:650).

Like menhaden, larval hickory shad resemble blueback in gross morphology, but have slightly fewer preanal myomeres than do alewife. Illustrations and data presented by Mansueti (1962) indicate that hickory shad (9.0 to 16.0 mm TL) possess 36 to 41 preanal myomeres [$\bar{x}$ = 38.8].

Limited information is available on gizzard shad. Descriptions published by Miller (1960) provide no criteria for distinguishing this species from alewife or blueback at lengths less than 17.5 mm TL. A specimen (10.8 mm TL) figured by Miller has 44 preanal myomeres and 11 myomeres between the insertion of the dorsal fin and the vent. These counts are well within the range of those found for blueback of comparable size. However, gizzard shad 17.5 mm TL are reported by this author to have 22 rudimentary anal fin rays (30-34 rays at 20-22 mm TL), a number exceeding that attained by adult alewife or blueback. The assumption that no gizzard shad were included with specimens thought to be alewife or blueback is based on the relative scarcity of this species, and the fact that all the meristic and morphometric characters investigated were bimodally distributed. Were gizzard shad present, at least one character should be expected to show a trimodal distribution.

The only additional species in the Chesapeake Bay region

with which clupeid larvae may be confused is the bay anchovy whose young abound in brackish water of the estuaries. They may be identified by the position of the vent, which is located directly under the center of the dorsal fin. The vent of clupeids is positioned well posterior to the dorsal fin. Mansueti and Hardy (1967:89) report that the adult complement of 23 to 31 anal rays is often attained by larvae 7 to 8 mm TL - a characteristic which is useful for quickly distinguishing this species from the clupeids.

Criteria have been presented for distinguishing larval alewife from blueback herring. Methods of identifying the larvae of American shad have also been given. However, the foregoing discussion clearly indicates the need for a comparative study of all the clupeid species before their larvae can be identified with complete certainty.

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